REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	20 Nov. 95	01 Dec. 1989 - 31 May 1995

4. TITLE AND SUBTITLE
Multiscale, Multisensor Analysis of Surface Slope Distributions

5. FUNDING NUMBERS
G/C
N00014-90-J-1615

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8. PERFORMING ORGANIZATION REPORT NUMBER
131615SP

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
Code 3210A
Ballston Center Tower One
Arlington, VA 22217-5660

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

A primary objective for the series of ARSRP experiments is to improve the understanding of acoustic scattering mechanisms at medium and long ranges at shallow grazing angles. One of the most important goals of this program is to determine if sites of strong backscatter can be predicted deterministically from properties of the bottom and water column.

This study has the long-term objective of investigating whether the bright spots observed in the scattered data arise from discrete scattering targets, or from a large number of scatters interfering randomly within each resolution footprint. This work has natural and immediate extensions to shallow-water acoustic environments, where the source of scattering is also a priority.

14. SUBJECT TERMS
acoustic scattering
seafloor topography

15. NUMBER OF PAGES
2

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
U	U	U	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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Grant & Contract number N00014-90-J-1615

Multiscale, Multisensor Analysis of Surface Slope Distributions

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Long-Term Goals

A primary objective for the series of ARSRP experiments is to improve the understanding of acoustic scattering mechanisms at medium and long ranges at shallow grazing angles. One of the most important goals of this program is to determine if sites of strong backscatter can be predicted deterministically from properties of the bottom and water column.

This study has the long-term objective of investigating whether the bright spots observed in the scattered data arise from discrete scattering targets, or from a large number of scatterers interfering randomly within each resolution footprint. This work has natural and immediate extensions to shallow-water acoustic environments, where the source of scattering is also a priority.

Scientific and Technological Objectives

The primary hypothesis we have tested is whether the bright backscatter sites observed in the ARSRP reverberation data result from specific physical effects related to the rough bottom surface (intrinsic scattering strength), or are simply random occurrences resulting from interference (speckle) effects. A key to understanding whether acoustic scattering is random or determined by a specific physical mechanisms is to analyze the decorrelation of the scattering with look geometry, and compare these with predicted decorrelations based on known mechanisms.

A second, related objective of the research has been to determine whether scattering is controlled primarily by properties of the bottom or water column. In order to distinguish bottom effects from propagation effects, we seek to distinguish whether strong backscatter is associated with an intrinsic property of the bottom at that location, such as favorable back-facing reflector geometry or high backscatter rubble or similar material, or because the scattering occurs within a depth zone corresponding to low Transmission Loss (TL) through the water column.

This research, by concentrating on the direct-path insonification, has direct application to scattering mechanisms in the shallow water environment.

Background

Acoustic reverberation data collected at Site A in the 1993 Fine Scale Acoustics Cruise show a number of repeatable returns that appear to be directly linked to fine-scale bathymetry measured with the AMS-120 sonar in the 1993 G&G Fine Scale Cruise. The bathymetry in this region consists of a series of abyssal hills plunging into the nearby sediment pond. Acoustic bright spots are found at a wide range of depths within this area and correlate closely

with areas of steep bathymetric gradients rather than with absolute bathymetric depth. It is noteworthy that the brightest scatterers originate mid-way down the plunging abyssal hills, rather than from the shallowest part of the data that extends further into the sound channel. This remarkable correlation with the fine-scale bathymetry strongly suggests that processes in addition to transmission loss create the fine-scale acoustic bright spots.

Because each beamformed, match-filtered resolution cell is many acoustic wavelengths across, the measured scattered amplitude results from the coherent sum of a large number of individual scattering centers that are located randomly within the footprint. As the insonification azimuth is varied, the relative phase contributions of the scattering centers change, altering the total amplitude, leading to a decorrelation of the scatterers with look angle.

Approach

We have investigated the spatial and angular decorrelation of these echoes by examining the changes in scattering strength associated with a patch of seafloor as the viewing geometry varies, and comparing these observations with predictive models to assess the importance of various decorrelation mechanisms.

The criterion for speckle interference establishes a characteristic angular decorrelation that is compared with the observed angular roll-off of scatter. This predicted decorrelation rate is also compared with predicted angular decorrelation that arises from the resolution footprint covering different scattering targets as the view angle changes. Because the interference mechanism decorrelates much more quickly than the footprint-coverage effect, the interference mechanism dominates.

Accomplishments and Results

Most scattering targets within Site A remain stable when viewed from the same look angle but differing range, emphasizing the repeatability of the scattering processes. As insonification azimuth is changed, scattering amplitudes are observed to systematically vary, until the entire scene appears quite different when viewed from azimuths differing by approximately 50°.

Investigation at ARSRP Site A of the detailed manner in which individual scattering targets vary with view angle reveals the exciting result that the observed angular decorrelation seems slower than that predicted by random speckle interference alone. This result is evidence that the scatterers are highly deterministic, even in their fine-scale character.

The results described above support the importance of bottom interactions in determining the details of acoustic scatter. While Transmission Loss (TL) has been shown to be important in determining the locations of regions of strong backscatter, this investigation, which targets the individual fine-scale scattering centers, finds these to be controlled less by TL effects, and instead by interactions with the bottom topography. Studying the decorrelation of scatter with azimuth is a powerful approach that can distinguish a number of candidate scattering mechanisms. Because of the strong dependence on bottom interactions rather than water-column TL effects, these analysis approaches and results can be readily integrated into acoustic studies in shallow water environments.